

CLAIMS

1. A method of controlling a continuously variable ratio transmission of the type comprising a continuously variable ratio unit ("variator") which has rotary input and output members through which the variator is coupled between an engine and a driven component, the variator receiving a primary control signal and being constructed and arranged such as to exert upon its input and output members torques which, for a given variator drive ratio, correspond directly to the control signal, the method comprising:

determining a target engine acceleration,

determining settings of the variator's primary control signal and of an engine torque control for providing the required engine acceleration and adjusting the control signal and/or the engine torque control based on these settings,

predicting a consequent engine speed change,

correcting the settings of the control signal and engine torque based on a comparison of actual and predicted engine speeds.

2. A method as claimed in claim 1 wherein allowance is made for engine characteristics in predicting engine speed change.

3. A method as claimed in claim 1 or claim 2 comprising calculating the instantaneous torque expected to be created by the engine and using the calculated torque value in predicting the engine speed change.
4. A method as claimed in any preceding claim wherein allowance is made for transmission characteristics in predicting the engine speed change.
5. A method as claimed in any preceding claim wherein the construction and arrangement of the variator is such that torques exerted by the variator upon its input and output members are proportional to magnitude of the primary control signal, for a given variator drive ratio.
6. A method as claimed in any preceding claim wherein the construction and arrangement of the variator is such that the sum of the torques exerted by the variator upon its rotary input and output members is always proportional to magnitude of the primary control signal.
7. A method as claimed in any preceding claim wherein the control signal takes the form of a difference between two hydraulic pressures.
8. A method as claimed in any preceding claim wherein the target engine acceleration is calculated based on a difference between current and target engine speeds.

- 43 -

9. A method as claimed in any preceding claim wherein target engine speed is set in dependence upon a user input.
10. A method as claimed in claim 9 wherein the user input is interpreted as a demand for a transmission output torque and engine speed.
11. A method as claimed in claim 10 wherein the driver's demands for transmission output torque and engine speed are modified based on engine efficiency considerations.
12. A method as claimed in any preceding claim wherein the demanded transmission output torque is converted to a target engine torque using a model of the transmission characteristics.
13. A method as claimed in any of claims 1 to 9 wherein, subject to limitations of the engine, a torque request to the engine torque controller is set to the sum of the target engine torque and the excess torque $TrqAcc$ required to accelerate power train inertia.
14. A method as claimed in any preceding claim wherein the engine's response to the torque controller is modelled to provide an estimate of instantaneous engine torque.
15. A method as claimed in claim 14 wherein the excess torque $TrqAcc$ required to accelerate the engine is subtracted from the estimated instantaneous engine torque to

obtain a required loading torque to be applied by the transmission to the engine, the variator control signal being adjusted to provide the required loading torque.

16. A method as claimed in any preceding claim wherein instantaneous values of engine torque and of loading torque applied to the engine by the transmission are estimated and used to calculate engine acceleration, the engine acceleration being integrated with respect to time to provide a prediction of engine speed, and closed loop control being applied to engine speed to correct it toward the predicted value.

17. A method of controlling a continuously variable ratio transmission of the type comprising a continuously variable ratio unit ("variator") which has rotary input and output members through which the variator is coupled between an engine and a driven component, the variator receiving a primary control signal and being constructed and arranged such as to exert upon its input and output members torques which, for a given variator drive ratio, correspond directly to the control signal, the method comprising:

determining a target engine acceleration,

determining an excess torque $TrqAcc$ required to accelerate power train inertia to achieve the target engine acceleration, and

- 45 -

adjusting the control signal to the variator and/or adjusting a torque controller of the engine such that engine torque is equal to loading torque applied by the transmission to the engine plus the excess torque $TrqAcc$.

18. A method as claimed in claim 17 wherein the construction and arrangement of the variator is such that torques exerted by the variator upon its input and output members is always proportional to magnitude of the primary control signal, for a given variator drive ratio.

19. A method as claimed in claim 17 wherein the construction and arrangement of the variator is such that the sum of the torques exerted by the variator upon its rotary input and output members is always proportional to magnitude of the primary signal control.

20. A method as claimed in any of claims 17 to 19 wherein the control signal takes the form of a difference between two hydraulic pressures.

21. A method as claimed in any of claims 17 to 20 wherein the target engine acceleration is calculated based on a difference between current and target engine speeds.

22. A method as claimed in any of claims 17 to 21 wherein target engine speed is set in dependence upon a user input.

23. A method as claimed in claim 22 wherein the user input is interpreted as a demand for a transmission output torque and for an engine speed.

24. A method as claimed in claim 23 wherein the driver's demands for transmission output torque and engine speed are modified based on engine efficiency considerations.

25. A method as claimed in any of claims 17 to 24 wherein the demanded transmission output torque is converted to a target engine torque using a model of the transmission characteristics.

26. A method as claimed in any of claims 17 to 25 wherein the engine's response to the torque controller is modelled to provide an estimate of instantaneous engine torque.

27. A method as claimed in claim 26 wherein the excess torque $TrqAcc$ required to accelerate the engine is subtracted from the estimated instantaneous engine torque to obtain a required loading torque to be applied by the transmission to the engine, the variator control signal being adjusted to correspond to the required loading torque.

28. A method as claimed in any of claims 17 to 27 wherein instantaneous values of engine torque and of loading torque applied to the engine by the transmission are estimated using engine and transmission models and used to calculate engine

- 47 -

acceleration, the engine acceleration being integrated with respect to time to provide a prediction of engine speed and closed loop control being applied to the engine speed to correct it toward the predicted value.

29. A method of controlling engine speed error in a motor vehicle powertrain comprising an engine which drives at least one vehicle wheel through a transmission which provides a continuously variable ratio, the transmission being constructed and arranged to exert upon the engine a controlled loading torque and to permit the transmission ratio to vary in accordance with resultant changes in engine speed, so that engine acceleration results from application of a net torque, which is the sum of the loading torque and an engine torque created by the engine, to the inertias referred to the engine, the method comprising, in a feedback loop, the steps of

determining the engine speed error,

supplying the engine speed error to a closed loop controller which establishes a control effort, which is a correction to the net torque required to reduce the engine speed error,

establishing, taking account of the control effort, an allocation of the control effort between (i) adjustment of the engine torque and (ii) adjustment of the loading torque, and

effecting the adjustment(s).

30. A method as claimed in claim 29 wherein the control effort is preferentially allocated to the loading torque adjustment.

31. A method as claimed in claim 1 wherein the implementation of the control effort involves adjustment of the engine torque only when the control effort exceeds a threshold, the control effort being otherwise implemented by adjustment to the loading torque alone.

32. A method as claimed in any of claims 29 to 31 further comprising limiting the adjustment to the loading torque on the basis of the deviation in torque at the driven wheel ("wheel torque") which it creates.

33. A method as claimed in claim 32 wherein a maximum acceptable deviation of wheel torque is set as a function of any one or more of: driver's accelerator control position, vehicle speed and target wheel torque.

34. A method as claimed in claim 32 or claim 33 comprising the further step of calculating a maximum loading torque adjustment from a maximum acceptable wheel torque deviation.

35. A method as claimed in any of claims 29 to 34, wherein the adjustment of the engine torque is established by subtracting the loading torque adjustment from the control effort.

36. A method as claimed in any of claims 29 to 35, wherein the engine speed error is determined using a predicted engine speed.

37. A method as claimed in any of claims 29 to 36, wherein engine speed error is established by comparison of current engine speed with a predicted engine speed established by calculating engine acceleration on the basis of engine and transmission settings and integrating engine acceleration over time.

38. A method of controlling engine speed comprising establishing base requirements for engine and transmission settings taking account of driver input, predicting engine speed based upon actual engine and transmission settings, and modifying the base requirements for the engine and transmission settings by a method as claimed in any of claims 29 to 37, wherein the engine speed error is obtained by comparison of current and predicted engine speed values.

39. A method of engine speed control wherein base requirements for engine and transmission settings are established by a feed forward method and are adjusted by a feedback method as claimed in any of claims 29 to 38.

- 50 -

40. A method as claimed in claim 39 wherein the feed forward method preferentially controls engine speed using the engine and the feedback method preferentially controls engine speed error using the transmission.

41. A method as claimed in claim 39 or claim 40 wherein the feed forward method preferentially selects base transmission settings to provide a wheel torque demanded by the driver and selects base engine settings to achieve a desired engine speed.

42. A device adapted to implement the method claimed in any of claims 29 to 41.

43. A method as claimed in claim 13 wherein the feedback method involves preferentially adjusting the transmission settings to control engine speed error.